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(71) Applicant: TELIA AB [SE/SE]; Mårbackagatan 11, S-123 86 Farsta (SE).

(72) Inventor: KAVAK, Nail; Myrstuguvägen 359, S-143 32 Vårby (SE).

(74) Agent: KARLSSON, Berne; Telia Research AB, Rudsjöterrassen 2, S-136 80 Haninge (SE).

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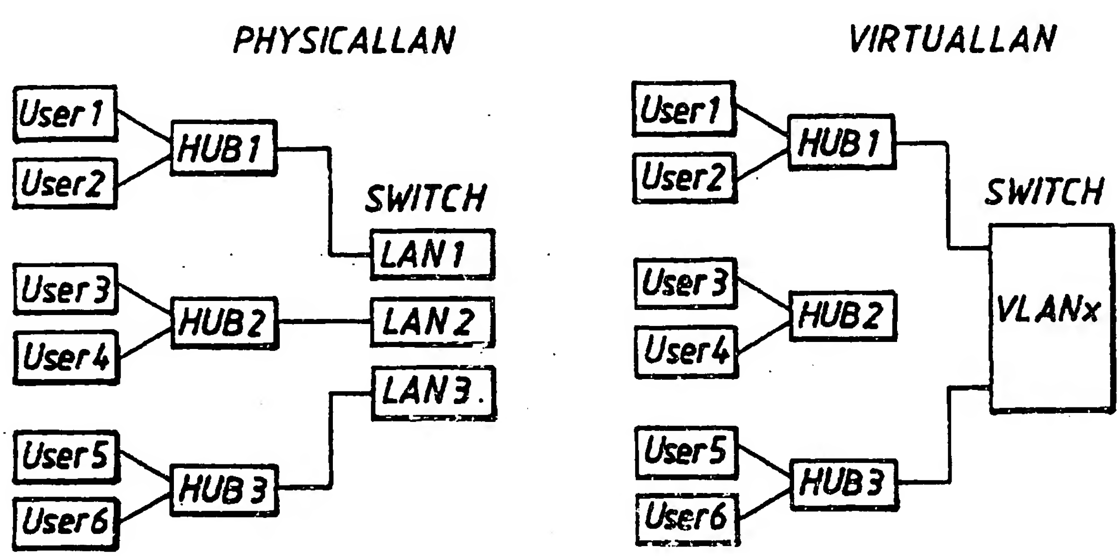


(57) Abstract

The present invention is a wireless high speed virtual LAN, particularly adapted for residential and small business use. Wireless access results in low cost and flexibility. Users are able, if necessary, to access a wired enterprise network and be connected to closed user groups at high speed. The VLAN concept enables increased flexibility in terms of system configuration, increased performance and increased security for both users and network operators. Users can logically change their group membership thereby gaining access to different network services without changing their physical location. Terminal mobility is enabled by provision of a seamless handoff scheme. System efficiency is enhanced by use of a path migration scheme which preserves data continuity and is transparent to users.

A WIRELESS ATM SWITCHED LOCAL AREA NETWORK SUPPORTING MOBILITY OF MOBILE TERMINALS

The present invention relates to a wireless ATM based virtual local area network (LAN) and, more particularly, such a LAN arranged to support seamless handoff between base stations and providing the ability to migrate transmission paths following handoff.

The rapid proliferation of portable commuters,, the availability of deregulated radio bandwidth and the prospect of reduced costs for office rearrangement has led to the emergence of wireless LANs as an interconnect technology. Wireless LANs enable the realisation of "computing anywhere at any time". Mobility and portability can be expected to create entire new classes of subscriber applications.

First generation wireless LANs are, in reality, mere extensions of traditional LANs, i.e. the extension of existing LANs by, e.g. radio, or infra-red, and are employed where wiring difficulties are encountered, for example factory floors, stock exchanges etc.. Wireless interconnections between LANs located in different buildings have also been provided.

End users may be given nomadic access to a wireless LAN via a central hub. Such access is particularly valuable to endusers who need to transfer large data files from a portable commuter to a backbone information network while returning to their offices. Wireless LANs may also be used to permit ad hoc networking between a group of portable users, e.g. in a class room, or meeting.

It can be expected that nomadic personal computing devices will, in the future, be universally used. Such

small business use. Wireless access results in low cost and flexibility. Users are able, if necessary, to access a wired enterprise network and be connected to closed user groups at high speed. The VLAN concept enables increased flexibility in terms of system configuration, increased performance and increased security for both users and network operators. Users can logically change their group membership thereby gaining access to different network services without changing their physical location. Terminal mobility is enabled by provision of a seamless handoff scheme. System efficiency is enhanced by use of a path migration scheme which preserves data continuity and is transparent to users.

According to a first aspect of the present invention, there is provided a wireless local area network having a plurality of mobile terminals and a plurality of wireless base stations linked by an infrastructure network, characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, and in that both intra-switch and inter-switch mobility is supported by said infrastructure network.

Central control means may be provided for reconfiguring the wireless local area network by reassigning logical addresses.

Said wireless local area network may be structured into a plurality of logical domains within which traffic can be confined and which exist independently of a mobile terminal's physical location.

Said wireless local area network may include overlapping logical domains.

whether a handoff is inter-switch, or intra-switch.

Preferably, a complete message, containing data on all MT-associated VCCs, is transmitted by an ATM switch, whenever the ATM switch has completed an SRD modification, to a new base station.

Preferably, each MT within an area served by an ATM switch has a unique VCI value.

First means may be provided for determining, after completion of an inter-switch handoff, whether, or not, communication is established over an optimum path, and second means may be provided to migrate said communication to an optimal path, if said path is sub-optimal.

A partner message may be employed to transmit an ATM address of a partner BS to an originating BS.

During path migration the flush message protocol of the LAN emulation protocol may be employed to maintain frame order.

According to a second aspect of the present invention, there is provided a wireless local area network having a plurality of mobile terminals and a plurality of wireless base stations linked by an infrastructure network characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, in that both intra-switch and inter-switch mobility is supported by said infrastructure network, in that central control means are provided for reconfiguring the wireless local area network by reassigning logical addresses, and in that there is provided an MVD and an SRD, in which an individual data direct VCC is established between each

- said MT issues a location message containing ATM addresses for said first and second BSs and a connection message to said second BS;

- the first BS transmits a routing message to the first ATM switching node;

- the first ATM switching node establishes an SVC to the second base station for each of the MT-associated VCCs;

- said first ATM switching node modifies duples corresponding to said MT-associated VCCs in an SRD located at said first ATM switching node;

- said first ATM switching node transmits a coupling message to the second base station;

- the second base station adds the new MT-pair VCC entry into its MVD; and

- the second base station re-starts data transmission.

If said second ATM switching node detects that an output port and an input port of a mobile connection are identical, so that a longer looped loop path exists, the following steps may be performed:

- said second ATM switching node releases the SVC established for the longer loop path;

- said second ATM switching node sends a routing message to a third adjacent ATM switching node;

- the third ATM switching node establishes a new

Figure 4 is a schematic illustration of a virtual wireless LAN, having an ATM network infrastructure, just before handoff.

Figure 5 is a schematic illustration of a virtual wireless LAN, having an ATM network infrastructure, immediately following an intra-switch handoff.

Figure 6 is a schematic illustration of a virtual wireless LAN, having an ATM network infrastructure, immediately following an inter-switch handoff.

To facilitate an understanding of the present invention a glossary of the abbreviations used in the specification is set out below:

ATM: Asynchronous Transfer Mode

BS: Base Station

BSA: Basic Service Area

BSS: Basic Service Set

IP: Internet Protocol

LAN: Local Area Network

LE: LAN Emulation

MAC: Medium Access Control

MT: Mobile Terminal

MVD: MT pair-VCC mapping Database

NNI: Network Node Interface

Traditional LANs must be reconfigured at the switching hub whereas VLANs can be reconfigured, by means of software driven processes, from a central controller, or server. Traditional LANs require that relocated stations be assigned new IP addresses. In a VLAN, only the logical address of relocated stations change, IP addresses remain the same. The VLAN hub performs the translation between IP address and logical address.

The simplest LANs support a single workgroup with a single shared medium communication path. As the number of users and the traffic increases, bridges can be employed to segment a LAN. However, users still share the same amount of bandwidth. Switching hubs use high-bandwidth backplanes to support multiple, separate, LAN segments and to offer dedicated bandwidth to high powered workstations. VLANs permit multiple workgroups, or logical domains, to be defined. Traffic can be restricted to the stations, servers and other resources allocated to a given logical domain. Overlapping, or cross domains, can be created to enable certain members of one domain to access members of another domain. Logical domains exist independently of their members' physical connections and may include members on more than one LAN segment. Because logical domains are easy to reconfigure, users can be regrouped faster and more frequently than is possible in the traditional LAN environment.

VLANs can restrict broadcasts to the logical domain in which they originate. Adding users to one domain does not affect the availability of bandwidth to users in other domains. As requirements change, workstations can be reassigned to other appropriate domains, or the domains themselves can be reconfigured. For example, several users working on a high bandwidth-intensive application might be grouped into a single logical

segments. The configuration is not physical, but rather logical. The switches are able to logically separate different broadcast domains. VLAN architecture offers three key advantages over basic switched LANs:

- logical, rather than physical, updating;
- inter-domain security; and
- reduced broadcast areas.

Turning now to Figure 2, there is illustrated a wireless VLAN according to the present invention. The basic building block of the wireless network is a radio cell called a basic service area. Each BSA, C_0 ..... C_7 is covered by a base station, labelled BS0 .... BS7, in Figure 2. The BSs exchange radio signals with mobile stations, not shown in Figure 2. A set of MTs, within a BSA, that are able to mutually communicate, is referred to as a Basic Service Set, or BSS. A wireless VLAN which comprises a single BSS has a limited range and can operate only within a local environment. To overcome the problem of range, several BSSs must be interconnected. This interconnection may be achieved via a wireline infrastructure network, a WAN, or the Internet. In such a system, BSs provide a wireless communications link between the backbone infrastructure network and mobile terminals. The backbone infrastructure network of the present invention is a switched ATM network comprising ATM switching nodes A ..... F, see Figure 2. The ATM network can operate on the basis of the LAN emulation (LE) defined in the ATM Forum. The LE enables, inter alia, connectivity between LAN bridges. One property of such a network is that all ATM cells, for frames transmitted between two LANs, are assigned the same VPI/VCI. The cells of the frame are reassembled at the destination bridge which forwards

routed to MT_j from MT_i must be forwarded from BS0 to BS1 by ATM switch C. However, ATM switches lack the capability to distinguish which cells on the VCC should be forwarded to BS1 rather than BS0. Thus, the only way to provide a seamless handoff is to establish a new VCC, designated VCC(0,1) between BS0 and BS1. In other words, BS0 must reassemble ATM cells destined for MT_j, check the destination address, which will have changed following the handoff, segment the ATM cells into ATM frames and forward the cells via the newly established VCC(0,1) to BS1. This approach is simple and straight forward and enables the original scheme for interconnection of wireline LANs to be applied directly. However, the communication path between MT_j and MT_i has been elongated, e.g. VCC(5,0) must be extended by the addition of VCC(0,1). This problem of path elongation is more serious in the case of inter-switch handoff. Consider the case in which MT_j moves from BSA C0 to BSA C3. In this case the communication path from MT_i to MT_j would be elongated from VCC(5,0) to VCC(5,0) + VCC(0,1) + VCC(1,2) + VCC(2,3), as shown in Figure 3. It is clearly desirable to have some mechanism which will permit an elongated communication path, to be migrated to a shorter communication path should such a shorter path be available. For example, as can be seen from Figure 3, it would be beneficial if path VCC(5,0) + VCC(0,1) + VCC(1,2) + VCC(2,3) could be migrated to a shorter path such as (BS5, F, A, D, BS3), or (BS5, F, D, BS3).

An intra-switch handoff can be readily achieved by informing the ATM switch node involved, (only one switch node is involved in an intra-switch handoff), to change the data path from one port to another, internally. Where an inter-switch handoff is required, it may be necessary to establish a shorter VCC, if possible. Thus, path migration is recommended as a means of

A handoff VC is defined by appropriate VPI/VCI values and is used to carry messages relating to MT mobility and handoff. The handoff VC is a point-to-point connection between a BS and an ATM switching node, or between two ATM switching nodes.

For the sake of simplicity, the term "mobile connection" is used to refer to the virtual connection between any pair of MTs. These mobile connections are dynamically established by signalling protocols.

Consider now, by way of example, the connection topology illustrated in Figure 4. Figure 4 shows three ATM switching nodes X, Y, Z and six BSAs, C_0 to C_5. Base stations (BS_0, BS_1), (BS_2, BS_3) and (BS_4, BS_5) are connected to ATM switches X, Y and Z respectively. Initially there are three mobile connections, namely (a,c), (b,c) and (a,d). Each mobile connection is identified by a sequence of VPI/VCI values, for (a,c), (b,c) and (a,d), these are:

(a,c) - (10/700,30/400,60/100);

(b,c) - (10/800,30/500,60/200); and

(a,d) - (10/900,30/600,60/300).

The VPI values are based on the assignment of virtual paths between two ATM switching nodes, or between an ATM switching node and a BS. Two, or more, MT handoff processes cannot be handled at the same time within an ATM switching node. It is, therefore, necessary to provide a mechanism for resolving handoff conflicts between MTs located within an area served by a single ATM switching node and having a unique VCI value. In the present example, the VCI is randomly selected and used only to identify an end-to-end mobile

An example of the procedure used to handle intra-switch handoff will now be described with reference to Figure 5, which shows the connection topology illustrated in Figure 4 after a mobile MT_c has moved from BSA C_0 to C_1. It is assumed that MT_c has initiated location and connection queries. It should be noted that MT_c has two mobile connections, namely with MT_a and MT_b. The steps used to implement an intra-switch handoff are as follows:

1. MT_c issues a location message containing the ATM address of BS_1 and BS_0, and a connection message with MT(a,c) - 60/100 and MT(b,c) - 60/200 to BS_1.

2. BS_0 then sends a routing message (60/100, 60/200, ATM BS_1) to ATM switching node X.

3. ATM switching node X modifies the corresponding duples of the MT-associated VCCs in the SRD and issues a complete message with all new VPI/VCI pairs, i.e. VCCs 70/100 and 70/200 to BS_1.

4. BS_1 adds the new MT-pair-VCC entries to its MVD and restarts the data transmission procedure.

Figure 5 shows the mobile connections and the contents of the corresponding MVDs and SRDs after the intra-switch handoff. The data paths are changed, from one ATM switch port to another, internally. The routing load on the ATM network due to intra-switch handoff is minimized and the communications path (VCC) is not elongated. Moreover, the MVD of BS_4 is not changed.

In the case of an inter-switch seamless handoff, it

3. ATM switch X establishes a SVC to BS_2 for each of the MT-associated VCCs (70/100 and 70/200), modifies the corresponding duples in its SRD, and sends a couple message with VCC 70/100 (70/200) to BS_2.

4. BS_2 adds the new MT-pair VCC entry into its MVD and restarts the data transmission procedure.

5. If the ATM switching node X detects that the output port and input port of a mobile connection are identical, i.e. a loop has occurred, it first releases the SVC established for the elongated path and sends a routing message to the adjacent ATM switching node, Z in the case of the present example, in the mobile connection path. The adjacent ATM switching node then establishes a new SVC to the new BS for the elongated path and also goes into a loop detection phase. If there is no loop, the handoff procedure is complete, otherwise this step of the procedure is repeated until all loops have been eliminated, working steadily back through the chain of ATM switching nodes in the mobile communication path, (in the present example this chain is only two switching nodes long).

Once handoff is completed, the elongated path created by inter-switch handoff has been reduced as much as possible by the handoff procedure itself. However, it is quite possible that the elongated path is not the shortest path between the two communicating MTs. A path migration can, if necessary, be applied to migrate the communications path created in the handoff process to a better path. Path migration is thus performed after completion of an inter-switch handoff. In the case of intra-switch handoff there is no need to consider path migrations, i.e. rerouting.

CLAIMS

1. A wireless local area network having a plurality of mobile terminals and a plurality of wireless base stations linked by an infrastructure network, characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, and in that both intra-switch and inter-switch mobility is supported by said infrastructure network.

2. A wireless local area network as claimed in claim 1, characterised in that central control means are provided for reconfiguring the wireless local area network by reassigning logical addresses.

3. A wireless local area network as claimed in either claim 1, or 2, characterised in that said wireless local area network is structured into a plurality of logical domains within which traffic can be confined and which exist independently of a mobile terminal's physical location.

4. A wireless local area network as claimed in claim 3, characterised in that said wireless local area network includes overlapping logical domains.

5. A wireless local area network as claimed in any previous claim, characterised in that terminal mobility is achieved by use of a seamless handoff scheme.

6. A wireless local area network as claimed in claim 5, characterised in that an individual data direct VCC is established between each pair of communicating mobile terminals.

7. A wireless local area network as claimed in either

13. A wireless local area network as claimed in any of claims 5 to 12, characterised in that a routing message includes data identifying MT-associated VCCs, an originating base station, and a new base station and enables an ATM switch to identify whether a handoff is inter-switch, or intra-switch.

14. A wireless local area network as claimed in any of claims 5 to 13, characterised in that a complete message, containing data on all MT-associated VCCs, is transmitted by an ATM switch, whenever the ATM switch has completed an SRD modification, to a new base station.

15. A wireless local area network as claimed in any previous claim, characterised in that each MT within an area served by an ATM switch has a unique VCI value.

16. A wireless local area network as claimed in any previous claim, characterised in that first means are provided for determining, after completion of an inter-switch handoff, whether, or not, communication is established over an optimum path, and in that second means are provided to migrate said communication to an optimal path, if said path is sub-optimal.

17. A wireless local area network as claimed in claim 16, characterised in that a partner message is employed to transmit an ATM address of a partner BS to an originating BS.

18. A wireless local area network as claimed in claim 16, characterised in that during path migration the flush message protocol of the LAN emulation protocol is employed to maintain frame order.

19. A wireless local area network having a plurality of

transmission.

21. In a wireless local area network as claimed in claim 19, a method of providing seamless inter-switch handoff, of a MT from a first BS, connected to a first ATM switching node, to a second BS, connected to a second ATM switching node, characterised by the following steps:

- said MT issues a location message containing ATM addresses for said first and second BSs and a connection message to said second BS;
- the first BS transmits a routing message to the first ATM switching node;
- the first ATM switching node establishes an SVC to the second base station for each of the MT-associated VCCs;
- said first ATM switching node modifies duples corresponding to said MT-associated VCCs in an SRD located at said first ATM switching node;
- said first ATM switching node transmits a coupling message to the second base station;
- the second base station adds the new MT-pair VCC entry into its MVD; and
- the second base station re-starts data transmission.

22. A method as claimed in claim 21, characterised in that, if said second ATM switching node detects that an output port and an input port of a mobile connection are identical, so that a longer looped loop path exists, the

Fig. 1

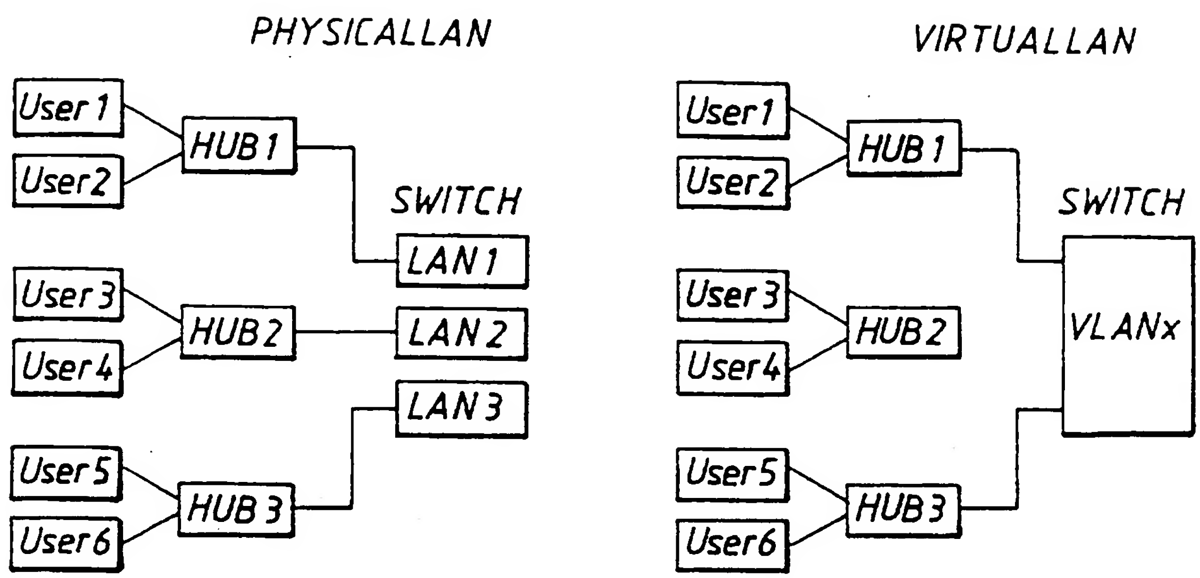

PHYSICALLAN
User 1
User2
HUB 1
SWITCH
LAN 1
User 3
User 4
HUB 2
LAN 2
LAN 3
User 5
User 6
HUB 3
VIRTUALLAN
User1
User2
HUB 1
SWITCH
User 3
User 4
HUB 2
VLANx
User 5
User 6
HUB 3

Fig. 2

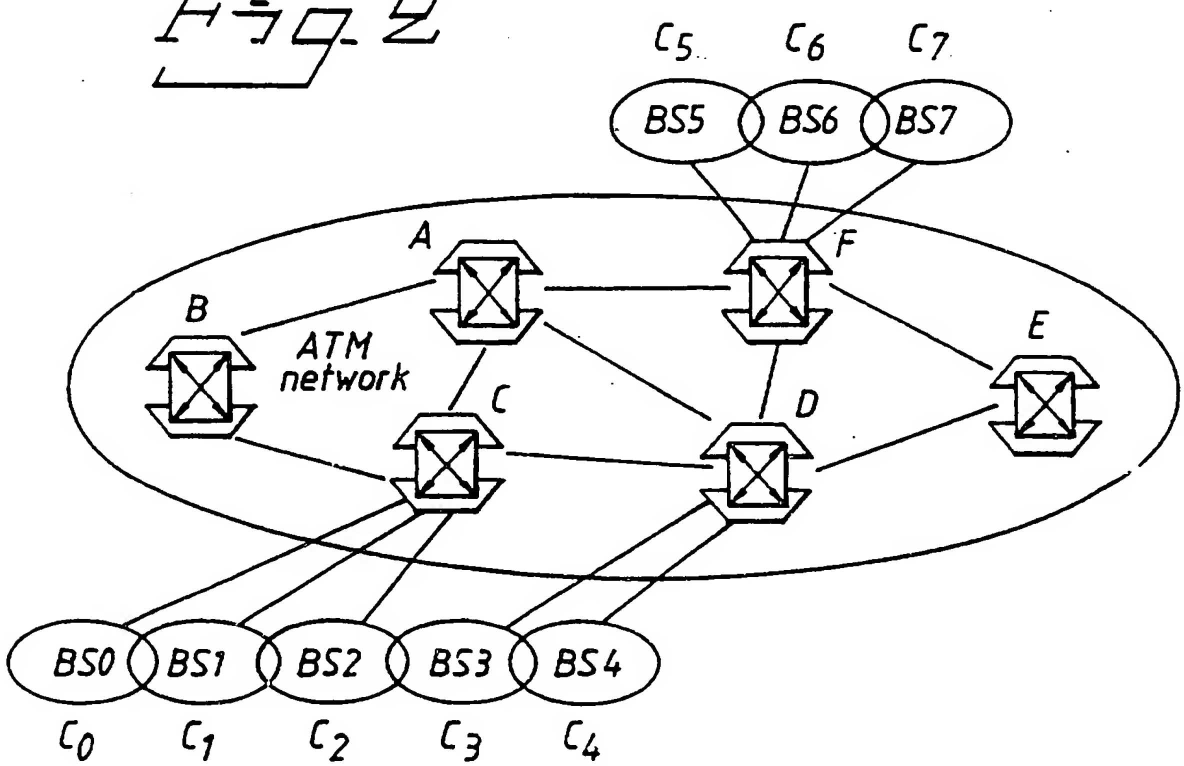
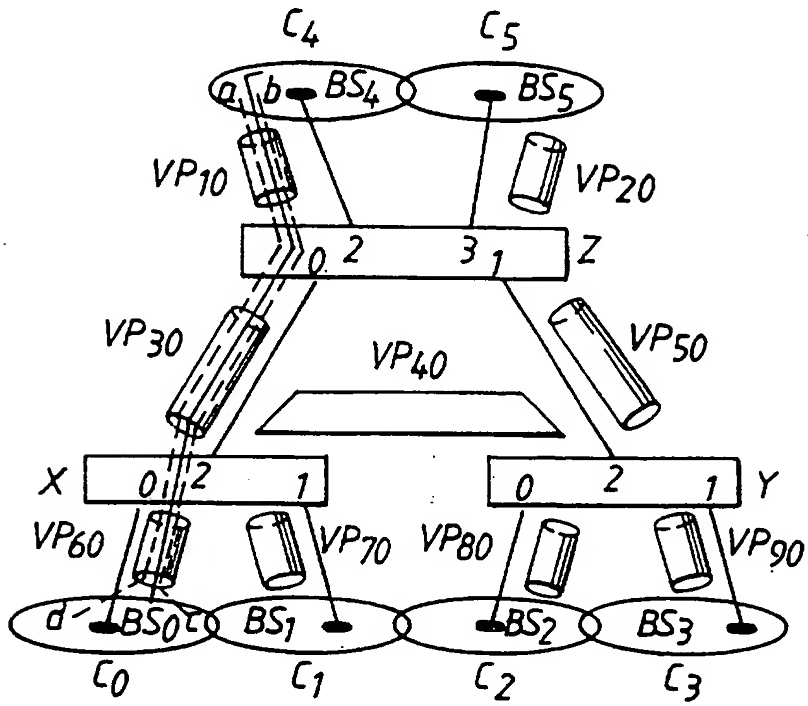

C5
C6
C7
BS5
BS6
BS7
A
F
B
ATM
network
E
C
D
BS0
BS1
BS2
BS3
BS4
C0
C1
C2
C3
C4

Fig. 4



BS0's MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 60/100
MT(b,c) - 60/200
MT(a,d) - 60/300

Switch X's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
60/100	0	30/400	2
30/400	2	60/100	0
60/200	0	30/500	2
30/500	2	60/200	0
60/300	0	30/600	2
30/600	2	60/300	0

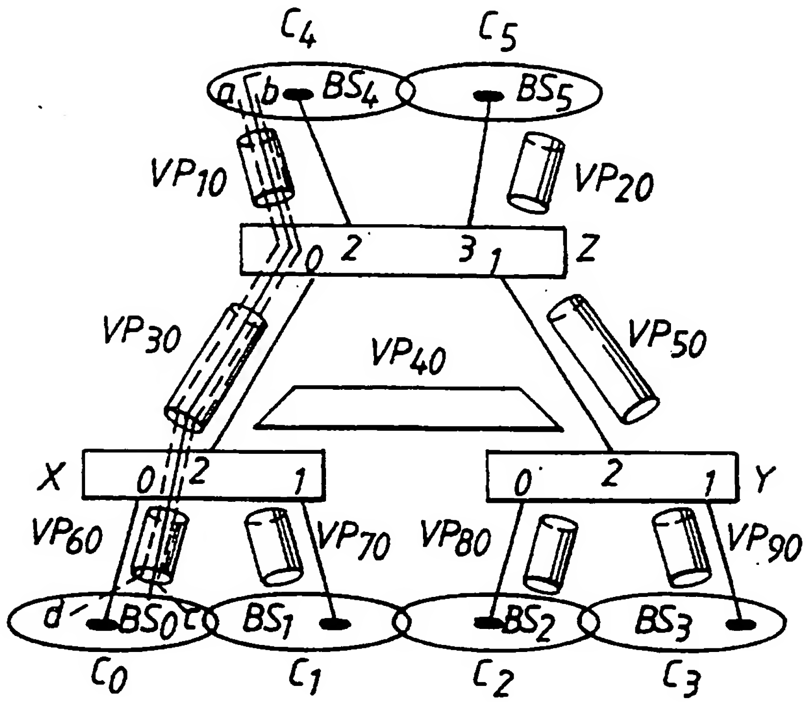
BS4's MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 10/700
MT(b,c) - 10/800
MT(a,d) - 10/900

Switch Z's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
30/400	0	30/400	2
10/700	2	60/100	0
30/500	0	30/500	2
10/800	2	60/200	0
30/600	0	30/600	2
10/900	2	60/300	0

Fig. 6



BS$_2$'s MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 80/350
MT(b,c) - 80/450

Switch Y's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
80/350	0	50/150	2
50/150	2	80/350	0
80/450	0	50/250	2
50/250	2	80/450	0

BS$_4$'s MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 10/700
MT(b,c) - 10/800
MT(a,d) - 10/900

Switch Z's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
30/400->50/150	0->	10/700	2
10/700	2	30/400->50/150	0->1
30/500->50/250	0	10/800	2
10/800	2	30/500->50/250	0->1
30/600	0	10/900	2
10/900	2	30/600	0

INTERNATIONAL SEARCH REPORT
Information on patent family members

20/05/97

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PCT/SE 97/00108

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